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APPROACH OF THE IMPLEMENTATION OF PRESSURE SENSORS IN UP-TO-DATE MEASURING SYSTEM USING IEEE 1451 STANDARD

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Abstract **– The up to date level involves tendency of using the sensors and transducers measuring fields. This paper presents a condensed review of nowadays pressure sensors technology, problem implicated and some modern tendencies. In this paper sensitive pressure sensor with nitride membrane and optoelectronic read-out system is described. Measured pressure is transformed into thick layer nitride membrane deflection. A new type of optical read-out technique for pressure sensors with thin nitride diaphragm has been developed and tested. Main advantages of the sensor are wide dynamic range of measured pressure with excellent resolution. IEEE 1451.2 capabilities were implemented in pressure sensor.**

Keywords: *pressure sensors, implementation, IEEE 1451 standard, nitride membrane, optoelectronic.*

1. PRESENT BACKGROUND

At present, measurement is a field of great interest because its various possibilities measurements can be used with great efficiency and results. The improvement of the measurement means has conditioned and allowed new discoveries in science and technique. This thing has reflected upon the achievement of some exact quick and flexible measurement means. The increase in using the measurement, control and data transfer digital systems requires the use of digital sensors and transducers. In this paper will achieve a concise description of those.

Every transducer may be equipped with a digital output by attaching some electronic conversion circuits. In one form of digital transducer, an analog effect such as a change in resistance or a change in tension on a wire can be operated on by hybrid electronic circuitry to produce a frequency or pulse train.

They are analogue signals which can be easy processed without the achievement of the analogue-digital conversion operation. Unlike the signals, using the digital signals is fat too easy.

The current tendency is to implement a larger part of the functionality of the measurement system with the help of digital modules. The electric and electronic instrumentation is used on large scale for measuring a significant number of no electrical dimensions in various fields of activity. The use of the technological processes, by introducing the computer in data processing and by using the remote measuring systems. Among the applications of scientific nature that play a major part in the measurement field we should mention the measuring systems with virtual instrumentation. The virtual instruments achieved through software extend the options of the real ones.

Virtual instrumentation use : sensors and transducers to contact the measured physical dimensions; signal conditioning systems; signal conditional circuits and circuits for analogical- computational conversion. Virtual instruments have because of its flexibility and inconstancy a huge potential for those that work in the field of education, science and technology. The virtual instrumentation system becomes complex and strong "tools" of monitoring and controlling the industrial processes. The advantages implied by using the virtual instruments develop new applications in the field at measurements and new opportunities for research.

Smart sensors - enable users and systems integrators to automatically configure their measurement automation systems for analog sensors.

Virtual Transducer Electronic Data Sheets (TEDS) sensors are rapidly being deployed into a variety of test and measurement applications. TEDS enable data acquisition (DAQ) system to detect and automatically configure sensors. This technology provides:

- Reduced configuration time by eliminating manual data entry;
- Better reliability by storing data sheets electronically;
- Improved accuracy with detailed calibration information;
- Simplified of sensor companies offer compatible sensors.

Dozens of sensor companies offer compatible sensors.

Sensors plug-and-play is revolutionizing measurement and automation, [1].
The achievement of complex measurement systems, computerized systems is an actual desire.
The smart transducers are the most developed transducers. These rule out the necessity of other circuits or devices in the system. They can be introduced in the network- working in "plug-and-play" system becomes practical. With such transducers we achieve measurement systems that offer flexibility and versatility.
This paper presents a condensed review of nowadays pressure sensors technology, problem implicated and some modern tendencies.
Standard IEEE 1451 family is made up of advanced transducers that can be coupled in networks. The IEEE standard specifies a collection of standard Transducer Electronic Data Sheet (TEDS) formats (for different sensor types). In our (this) paper sensitive pressure sensor with nitride membrane and optoelectronic read-out system is described. Measured pressure is transformed into thick layer nitride membrane deflection. Double current signal is amplified and conditioned digitally by ADuC812 microcomputer. This one chip microcomputer provides an IEEE 1451.2 interface. A new type of optical read-out technique for pressure sensors with thin nitride diaphragm has been developed and tested. Main advantages of the sensor are wide dynamic range of measured pressure with excellent resolution. IEEE 1451.2 capabilities were implemented in pressure sensor.

2. HOT POINTS OF THE DEVELOPMENT PRESSURE SENSORS

The sensor is a device that measures a physical attribute or a physical event. It outputs a functional reading of that measurement as an electrical, optical or digital signal.
Technological development has brought a variety of complex digital output sensors to the market.
Because of the great variety of conditions, ranges, and materials for which pressure must be measured, there are many different types of pressure sensor designs.
Of all the pressure sensors, Wheatstone bridge (strain based) sensors are the most common, offering solutions that meet varying accuracy, size, ruggedness, and cost constraints. Bridge sensors are used for high and low pressure applications, and can measure absolute, gauge or differential pressure, [2].
A variable capacitance pressure transducer measures the change in capacitance between a metal diaphragm and a fixed metal plate. These pressure transducers are generally very stable and linear, but are complicated to setup than most pressure sensors.
Piezoelectric pressure transducer takes advantage of the electrical properties of naturally occurring crystal such as quartz. Piezoelectric pressure sensors do not require an external excitation source and are very rugged. The sensors however, do require charge amplification circuitry and very susceptible to shock and vibration, [3].
I'll present a condensed review of nowadays of development in digital pressure sensors and transducers domain.
Due to its well established electronically properties as well as its mechanical properties, crystal silicon is used more and more in a variety of new sensors and transducers. High performance, integrated transducers are made and they are easily interfaced with microcontrollers. Microelectronic silicon devices have the biggest success in the miniaturization tendency.
Micro processing is a new concept of making of sensors with processing of μm order. In this way were made pressure sensors with the diameter below 0.2 μm. production costs have dropped. Sensors performances have increased.
The sensors obtained with micro processing are used for measurements of vibrations, force and pressure, obtaining very high accuracy.
Monolithically integration was made together with microelectronic, micromechanical or optoelectronic circuits for broadening the range of application, [4].
National Instruments (NI) provides a broad range of pressure measurement solutions with several advantages over traditional pressure measurement and logging systems, [5]. NI pressure measurement systems use the concept of virtual instrumentation to provide increased flexibility and additional analysis capabilities at a lower cost. A virtual instrument consists of an industry - standard computer or workstation equipped with application software, hardware such as plug-in boards, and driver software, which work together to perform the functions of traditional measurement devices and instruments.
Pressure sensors should be selected based upon operating environment, desired measurement range, size, accuracy and cost.
Ultrasonic silicon surface micro tubes sensors, apart from piezoelectronically sensors, have a dynamic range in the air with 50dB better. The micro tube consists of a fine nitride membrane, whereon is laid an aluminum electrode, suspended on a vacuous space. These sensors can create more efficiently pressure ultrasonic than a solid piezoelectric crystal. Due to their small dimensions they can function at high frequencies.

3. SCIENTIFIC AND TECHNICAL DESCRIPTION OF THE SYSTEM

A new concept of sensor for pressure measurement is the sensitive pressure sensor with nitride membrane and optoelectronic read-out system. Measured pressure is transformed into thick layer nitride membrane deflection. A microelectronic sensor for low-level pressures measuring is a problematic matter. There are technological troubles with creating a pressure sensor with diaphragm for sensing pressure under 5kPa.

Using suitable diaphragm and measuring the distortion caused by the external pressure usually do acquisition of the pressure. Optical methods exploit changing intensity of modulated light caused by the external pressure. An optical read-out has several advantages over other technologies:

- A simple encapsulation;
- Small temperature coefficients;
- High resolution and accuracy.

Especially promising are the optoelectronic sensors operating with the light interference phenomena.

Many diaphragm-based optical sensors have been reported which measure pressure induced deflection using Mach-Zehnder interferometers and Fabry-Perot interferometers, [6].Drawback of this solution is a relative difficult design.

I use LPCVD silicon nitride (Si_3N_4) diaphragm created on the Si (100) wafer for sensing pressure element. The clean (100) wafer is coated with 160nm of silicon nitride prepared by low-pressure chemical vapor deposition (LPCVD).

Source of the laser beam is microelectronic laser FLEXPOINT 67/1AF-AV type with glass lens for laser beam focusing. Laser wavelength is 620 nm and power 0.4mW.

The position sensing device (PSD) measures position of the laser beam mark. I use a one-dimensional sensor 1L5SP type. This is a product of the SiTek Electro Optics. PSD is a lateral photodiode in that incident light generates photoelectrical current. Sensor output current signal is conditioned digitally using Analog Devices ADuC812 microcomputer.

The ADuC812 microprocessor is a basic building block of our pressure smart sensor. This product includes on-chip high performance multiplexers, analog digital converter (ADC), digital analog converter (DAC), FLASH program and data storage memory, an industrial standard 8052 microcontroller core and support several standard serial ports.

The microcontroller may also access to nonvolatile memory that contains a Transducer Electronic Data Sheets (TEDS) and to ten wires Transducer Independent Interface (TII). The one chip microcomputer provides an IEEE 1451.2 interface. The dimension of our pressure sensor is compromise between sensitivity and overall size.

The measuring system of pressure is shown in figure 1:

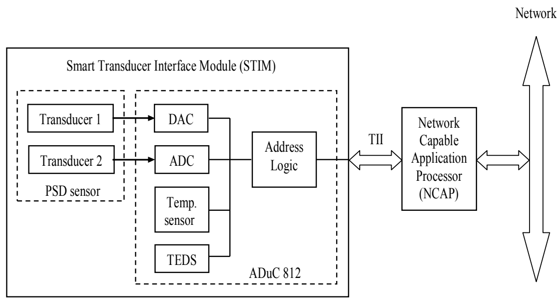

Figure 1: IEEE 1451.2 standard, implementation on the pressure sensor

Standard IEEE1451 family is made up of advanced transducers that can be coupled in networks, starting from interfacing the transducer up to a superior level, representation of conduct with an object pattern, attributed and data communications, [7]. The standards are written for transducers. The architecture includes a network, a processor able to work in a network, and an interface module for advanced transducers. Between the network and the interface module is the Independent Transducer Interface (TII).

There are four compelling reasons for developing a plug-and-play standard for smart sensors. IEEE 1451 is a developing standard that can make all complying sensors, instruments and systems work together with relative ease:

1. There are more than 3.000 global sensor manufactures. Trying to use a variety of sensors from a number of different manufacturers together in a data acquisition system can be very complex and require expensive customization by the integration team;
2. A conventional sensor system has a lot of analog wiring and extensive switching. IEEE 1451 systems will greatly simplify development and installation of smart sensors systems;
3. IEEE 1451 compliant systems will cost significantly less to install than conventional sensor systems;
4. Several factors make IEEE 1451 the right standard at the right time to capitalize on this extremely high growth rate. Semiconductor manufacturing techniques can make a wide variety of sensors far easier and cheaper to manufacture in quantity. These techniques can also be applied to nano development and wirelessly deployed, reducing the cost of installation. IEEE 1451 can enable networks of smart sensors to communicate and even to set up adhoc networks, [8].

IEEE 1451 is a planed set of standards for smart sensors that will make it easier and cheaper to deploy a wide variety of sensors. The IEEE 1451.2 is a Wired Transducer Interface - 12 wire bus working on a revision which will put IEEE 1451 on RS 232, RS 485 and USB, [9].

The IEEE 1451 standard specifies a collection of standard TEDS formats, defined as templates, for different sensor types. The templates provide the means for the measurement system to convert the binary data stored on a smart TEDS sensor EEPROM into meaningful specifications for that sensor. The collection of IEEE standard templates include IEPE accelerometers and microphone, IEPE pressure sensors, RTDs, thermistors, LVDT/RVDT, resistive sensors, and amplified sensors with voltage or current outputs, [10].

Figure 1 shows basic components of an IEEE1451.2 compatible system. The pressure sensor is referred to as a Smart Transducer Interface Module (STIM).

The STIM contains:

- The TEDS which stores sensor specifications;
- Transducers (transducer1 and transducer2) - temperature and the position sensing device (PSD) sensor;
- Necessary signal conditioning and as analogue-to-digital conversion;
- Simple discrete digital input/output (DI/O);
- Logic circuitry to facilitate digital communicates between the STIM and NCAP.

Trough a 10-Wire digital communication interface TII, the NCAP or networked host can initiate sensor readings, as well as request TEDS data.

4. CONCLUSIONS

Some digital transducers (or pseudo digital) are quite practical, some are speculative and some would survive only in a laboratory environment. Only a small number will be considered as measurement areas. The utilization of such up-to-date essential elements in any technical system is compulsory and followed by technical advantages and a better management. New type of optical read-out technique for pressure sensors with thin nitride diaphragm has been developed and tested. Main advantages of the sensor are wide dynamic range of measured pressure with excellent resolution. IEEE1451.2 capabilities were implemented in the pressure sensor.

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